

WHAT IS CLAIMED IS:

- 1 1. A method for measuring a physiological parameter, comprising:
2 measuring a plurality of signals, wherein each of said signals comprises a
3 source component corresponding to said physiological parameter and an interference
4 component;
5 processing said plurality of signals to obtain a plurality of principal
6 components;
7 processing said plurality of principal components to obtain a plurality of
8 independent components, wherein a matrix of said plurality of signals corresponds to a matrix
9 product of a matrix of said plurality of independent components and a matrix of mixing
10 coefficients; and
11 extracting a first measure of said physiological parameter corresponding to
12 said source component from one of said plurality of independent components.

- 1 2. The method of claim 1 wherein said physiological parameter is a
2 function of an oxygen saturation.

- 1 3. The method of claim 1 wherein said physiological parameter is a
2 function of a pulse rate.

- 1 4. The method of claim 1 wherein said plurality of signals corresponds to
2 sensed optical energies from a plurality of wavelengths.

- 1 5. The method of claim 1 wherein said plurality of signals corresponds to
2 sensed optical energies from a plurality of wavelengths from different times.

- 1 6. The method of claim 1 wherein said processing said plurality of signals
2 further comprises
3 obtaining a time derivative of the sensed optical energies from a plurality of
4 wavelengths.

- 1 7. The method of claim 1 wherein said interference component comprises
2 signal components caused by motion, respiratory artifact, ambient light, optical scattering and
3 other interference between a tissue location being sensed and a sensor.

1 8. The method of claim 1 wherein said processing said plurality of signals
2 further comprises decorrelating said plurality of signals by minimizing a cross-correlation of
3 said plurality of signals, to obtain a plurality of decorrelated signals; and
4 normalizing said plurality of decorrelated signals to obtain a plurality of
5 principal components.

1 9. The method of claim 1 wherein said processing said plurality of signals
2 comprises decorrelating said plurality of signals by singular-value decomposition of said
3 plurality of signals, to obtain a plurality of principal components.

1 10. The method of claim 1 wherein said processing said plurality of signals
2 comprises decorrelating said plurality of signals by multiplying said plurality of signals by
3 the inverse square root of the covariance matrix of said plurality of signals to obtain a
4 plurality of principal components.

1 11. The method of claim 1 wherein said processing of said plurality of
2 principal components comprises higher-order decorrelation of said plurality of principal
3 components.

1 12. The method of claim 1 wherein said processing said plurality of
2 principal components comprises maximizing a function of the higher-order cumulants of a
3 mixture of said plurality of signals, thus separating said source component from said
4 interference component.

1 13. The method of claim 12 wherein said higher-order cumulant is
2 cumulant having order greater than two.

1 14. The method of claim 12 wherein said higher-order cumulant is a third-
2 order cumulant of said plurality of signals.

1 15. The method of claim 12 wherein said higher-order cumulant is a
2 fourth-order cumulant of said plurality of signals.

1 16. The method of claim 1 further comprising obtaining a ratio of mixing
2 coefficients from said matrix of mixing coefficients, wherein said ratio corresponds to a ratio
3 of modulation ratios of red to infrared signals, wherein said plurality of signals comprise
4 modulated optical signal in the red and infrared ranges.

1 17. The method of claim 1 further comprising extracting a second measure
2 of said physiological parameter from said ratio, wherein said second measure of said
3 physiological parameter corresponds to an oxygen saturation.

1 18. The method of claim 1 wherein said first measure of a physiological
2 parameter corresponds to a pulse rate.

1 19. The method of claim 1 further comprising extracting said interference
2 component from another one of said plurality of independent components.

1 20. A pulse oximeter, comprising:
2 a sensor configured for measuring a plurality of signals, wherein each of said
3 signals comprises a source component corresponding to said physiological parameter and an
4 interference component;
5 a computer useable medium having computer readable code embodied therein
6 for measuring a physiological parameter, said computer readable code configured to execute
7 functions comprising:

8 processing said plurality of signals to obtain a plurality of
9 principal components;
10 processing said plurality of principle components to obtain a
11 plurality of independent components, wherein a matrix of said plurality of signals
12 corresponds to a matrix product of a matrix of said plurality of independent
13 components and a matrix of mixing coefficients; and
14 extracting a first measure of said physiological parameter
15 corresponding to said source component from one of said plurality of
16 independent components.

1 21. The pulse oximeter of claim 20 wherein said physiological parameter
2 is an oxygen saturation.

1 22. The pulse oximeter of claim 20 wherein said physiological parameter
2 is a pulse rate.

1 23. The pulse oximeter of claim 20 wherein said plurality of signals
2 corresponds to sensed optical energies from a plurality of wavelengths.

1 24. The pulse oximeter of claim 20 wherein said plurality of signals
2 corresponds to sensed optical energies from a plurality of wavelengths from different times.

1 25. The pulse oximeter of claim 20 wherein said plurality of signals
2 corresponds to the time derivative of the sensed optical energies from a plurality of
3 wavelengths.

1 26. The pulse oximeter of claim 20 wherein said interference component
2 comprises signal components caused by motion, respiratory artifact, ambient light, optical
3 scattering and other interference between a tissue location being sensed and a sensor.

1 27. The pulse oximeter of claim 20 wherein said processing said plurality
2 of signals comprises decorrelating said plurality of signals by minimizing a cross-correlation
3 of said plurality of signals, to obtain a plurality of decorrelated signals; and
4 normalizing said plurality of decorrelated signals to obtain a plurality of
5 principal components.

1 28. The pulse oximeter of claim 20 wherein said processing said plurality
2 of signals comprises decorrelating said plurality of signals by singular-value decomposition
3 of said plurality of signals, to obtain a plurality of principal components.

1 29. The pulse oximeter of claim 20 wherein said processing said plurality
2 of signals comprises decorrelating said plurality of signals by multiplying said plurality of
3 signals by the inverse square root of the covariance matrix of said plurality of signals to
4 obtain a plurality of principal components.

1 30. The pulse oximeter of claim 20 wherein said processing of said
2 plurality of principal components comprises higher-order decorrelation of said plurality of
3 principal components.

1 31. The pulse oximeter of claim 20 wherein said processing said plurality
2 of principal components comprises maximizing a function of the higher-order cumulants of a
3 mixture of said plurality of signals, thus separating said source component from said
4 interference component.

1 32. The pulse oximeter of claim 31 wherein said higher-order cumulant is
2 cumulant having order greater than two.

1 33. The pulse oximeter of claim 31 wherein said higher-order cumulant is
2 a third-order cumulant of said plurality of signals.

1 34. The pulse oximeter of claim 31 wherein said higher-order cumulant is
2 a fourth-order cumulant of said plurality of signals.

1 35. The pulse oximeter of claim 20 wherein said processing said plurality
2 of principal components comprises successive transformations to simultaneously minimize
3 second- and higher-order correlations among the outputs.

1 36. The pulse oximeter of claim 20 wherein said processing said plurality
2 of principal components comprises successive rotations to minimize estimated mutual
3 information among the outputs.

1 37. The pulse oximeter of claim 20 further comprising obtaining a ratio of
2 mixing coefficients from said matrix of mixing coefficients, wherein said ratio corresponds to
3 a ratio of modulation ratios of red to infrared signals.

1 38. The pulse oximeter of claim 20 further comprising extracting a second
2 measure of said physiological parameter from said ratio, wherein said second measure of said
3 physiological parameter corresponds to an oxygen saturation.

1 39. The pulse oximeter of claim 20 wherein said first measure of a
2 physiological parameter corresponds a pulse rate.

1 40. The pulse oximeter of claim 20 further comprising extracting said
2 interference component from another one of said plurality of independent components.